<table>
<tr><td colspan="4">Proposal Submitted to: [ ] Safety-IDEA [ ] NCHRP-IDEA [ ] Transit-IDEA [X] Reliability IDEA</td></tr>
<tr><td>For Use by TRB</td><td>Date Received</td><td colspan="2">Proposal Number</td></tr>
<tr><td>Title of Project: Testing Small Unmanned Aircraft to Support Roadside Avalanche Control Operations</td><td colspan="3">[ ] Concept Exploration (Type 1)
[X] Product Application (Type 2)
Project Duration __12_____ months</td></tr>
<tr><td>Submission Date:</td><td colspan="3">Signed, unaltered, NRC liability certification enclosed with the proposal [ ] Yes [ ] No</td></tr>
<tr><td rowspan="2">Name/Address of Submitting Organization and Business Contact
University of Washington:</td><td>Telephone</td><td colspan="2">Fax</td></tr>
<tr><td colspan="3">IDEA Budget $91,887 +Cost Sharing $32,780
= Total Project Cost $124,667</td></tr>
<tr><td>Business Type
[X] Academic [ ] Profit [ ] Non-Profit</td><td colspan="3">Size (Number of Employees)
[ ] <10 [ ] <100 [ ] <200 [X] >200</td></tr>
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<tr><td colspan="4">Names of other Key Investigators: Jamie Yount, Wyoming Department of Transportation</td></tr>
<tr><td colspan="4">Brief Summary of Concept and Potential Impact on Practice

A number of the western states have travel corridors that cross through mountainous terrain. In the winter, keeping these roads open for safe and reliable winter travel requires that state DOTs operate avalanche control programs that monitor snow conditions and trigger controlled avalanches. To be safe, this avalanche control process may require these corridors to be closed for lengthy periods, and these unpredictable closures negatively impact travel reliability. This IDEA program application will test small unmanned aircraft as another tool for DOT avalanche control staff to use that will help them open roadways more quickly. Previous tests have indicated that these aircraft are affordable and can be operated by DOT staff. This project will test whether these aircraft can carry sensors and cameras to provide aerial information of snow conditions, can inspect avalanche control target zones for people before the use of explosives, and can accurately drop charges to trigger controlled avalanches. The values of these capabilities in reducing the duration of road closures and increasing reliability will be evaluated and quantified.</td></tr>
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TESTING SMALL UNMANNED AIRCRAFT TO SUPPORT ROADSIDE AVALANCHE CONTROL OPERATIONS

SUMMARY OF CONCEPT AND ITS APPLICATION FOR PRACTICE

(a.) Concept and Application

A number of western states have important travel corridors that cross mountainous terrain and over high-altitude passes. In the winter, keeping these roads open for safe and reliable winter travel requires that state DOTs operate avalanche control programs to both monitor snow conditions and trigger controlled avalanches before enough snow accumulates to create large and destructive snow slides. These avalanche control operations, while necessary to keep roads open, are costly, potentially dangerous, technically complicated, and time consuming.

Current avalanche control efforts involve a range of methods to trigger controlled avalanches. To trigger avalanches, DOTs may use surplus military tanks and howitzers that shoot explosives into avalanche prone areas, skiers or snowmobilers with handheld explosive charges, and, occasionally, airplanes or helicopters that drop charges. Each of these methods, while effective, is costly and can be dangerous if not conducted carefully. As a result, many mountain roads have to be closed for lengthy periods until avalanche control operations have been completed. These unpredictable closures negatively affect travel reliability.

This IDEA program application is proposing to test small unmanned aircraft as an additional tool for DOT avalanche control staff to use that will help them open roadways more quickly.

As spinoffs from defense applications, small civilian versions of unmanned aircraft (referred to as unmanned aircraft systems or UASs) are increasingly affordable and easy to operate. Recognizing their potential, in 2006 and 2007, the Washington State Department of Transportation (WSDOT) and the University of Washington (UW) tested the use of both rotary and fixed wing UASs in Washington state as a tool to support avalanche control operations. These initial proof of concept tests demonstrated that UASs have the potential to carry sensors and cameras to provide high quality aerial information about snow conditions both on and alongside roadways, inspect avalanche control target zones for people before the use of explosives, and accurately drop charges to trigger snow avalanches to support snow avalanche control operations. The findings also suggested that unmanned aircraft can improve the safety, effectiveness, and speed of avalanche control operations by reducing avalanche control personnel response time while also increasing safety for motorists and control staff. The project also determined that UASs are both affordable and operable by a state DOT. More information on these tests can be found in McCormack (2008 and 2009) and McCormack and Stimberis (2010).

These limited, initial UW/WSDOT flights, which were funded by WSDOT and the U.S. DOT, showed the promise of this technology. This IDEA project will benefit from the lessons learned in the first tests and will support more realistic evaluation of the UAS technology as a tool to benefit transportation organizations responsible for maintaining roadways in winter conditions. This IDEA project proposal also recognizes that UAS capabilities are best explored by completing field tests involving actual flights above roads that require avalanche control operations.

(b.) Potential Payoff for Practice

Many western states have major roads that travel through avalanche prone areas. Table 1 shows the locations of major travel corridors that require avalanche control operations by state DOTs.

TABLE 1 Roadways Requiring Avalanche Control Operations

Avalanche Hazards on the National Highway System:	
Alaska	SR9 on the Seward Highway from Anchorage
	R7 north of Juneau
California	80 at Donner Summit
	SR 50 at Econ Summit
	R 88 at Carson Pass (California side)
	R 120 at Yosemite National Park
Colorado	70 at the Eisenhower Tunnel
	SR 550 at Red Mountain
	SR 160 at Wolf Creek Pass
Montana	SR 89 at Glacier National Park
	SR 2 at Marias Pass
Nevada	SR 88 at Carson Pass (Nevada Side)
Utah	84 in Ogden Canyon
	SR 189 in Provo Canyon
Washington	90 at Snoqualmie Pass
	SR 2 at Stevens Pass
	USR 12 at White Pass
	US 20 in the North Cascades
Wyoming:	SR 89 at Yellowstone National Park
	SR 14 at Yellowstone National Park
	SR 189 in Hogback Canyon
Source: Revised from Winter Alpine Engineering (2004)	

Avalanche control programs (typically part of state DOTs' maintenance and operations) are focused on keeping a state's important travel corridors through the mountains open during winter conditions and, for some states, on protecting maintenance crews re-opening and plowing roadways in the spring after winter closures. State avalanche control operations are often expensive. One 2004 report calculated that state DOTs spent more than $6 million each year (Winter Alpine Engineering 2004). For example, WSDOT's annual avalanche control budget is more than $1 million. Wyoming Department of Transportation's (WYDOT)budget is $125,000, in addition to some significant investments in avalanche control infrastructure.

There are usually few problems justifying a DOT's control program from a cost perspective because any closure of a roadway is often considerably more costly than a

control program. In Washington, Interstate-90, the state's major east-west travel route, crosses Snoqualmie Pass in the Cascade Mountains. Between 2005 and 2010, this pass was closed an average of 240 hours a year because of avalanche threats and resulting control activities (WSDOT 2011). This was costly; WSDOT has estimated that each hour that I-90 is closed costs about $500,000 to the state's economy. The winter of 2007-2008 had notably heavy snowfall, and the pass was closed for over 600 hours. During this winter one four-day closure was estimated to cost the state $28 million (WSDOT 2008). This closure had a major impact on the freight community, since many stores and manufacturing processes require frequent and reliable deliveries. On a typical day this pass serves 6,500 trucks. Because an alternative route through the Cascade Mountains (SR 2) was also closed for avalanche control operations, hundreds of trucks were lined up waiting for the pass to open. In Wyoming, Teton Pass is not only the most hazardous road corridor but serves around 5,000 vehicles each day. The economic loss estimated for avalanche closures of this road are $10,000 an hour.

Avalanches occur when snow on a slope or in chute can no longer support its own weight, loses grip on a slope, and slides downhill. Such avalanches can be extremely powerful and can travel surprising long distances. There are numerous examples of cars and large trucks being pushed off the road, with occasional fatalities. Current avalanche control efforts involve surveying snow conditions to identify conditions conducive to slides, clearing the run-out zone of people and hazards, and then purposefully triggering smaller controlled avalanches before snow can accumulate to dangerous amounts. This process is part art and part science and involves identifying when and where to trigger an avalanche slope or chute. Often this involves using a range of methods to deliver explosives to set off the avalanche. DOTs use surplus military tanks and howitzers to shoot explosives into avalanche prone areas, skiers or snowmobilers to deliver handheld explosive charges, and sometimes helicopters or airplanes to bomb avalanches. Each of these methods has limitations and is expensive, slow, and involves some risk to humans or may require increasingly difficult to obtain military equipment.

Small unmanned aircraft offer an alternative method for both surveying snow conditions and avalanche areas and triggering controlled avalanches that potentially could be quicker, safer, and less costly than existing methods. UASs are a relatively new technology that has resulted from improved global positioning systems (GPS), better software, smaller computers and sensors, and material advances such as carbon fiber airframes. UASs have become smaller, more capable, and less expensive mainly because of military investment in the UAS industry. Current generation UASs can be transported in small vehicles and launched from a road or a small truck but are still large enough to be equipped with cameras that can provide high quality aerial information and can carry significant payload for bombing avalanches. In addition, these aircraft are capable of flying without direct human input, autonomously completing preset flight plans.

Previous tests with these smaller UAS conducted by this project's proposer indicated that this technology can repeatedly deliver dummy control explosives with 6-foot accuracy to predetermined locations. Avalanche control professionals, through experience, often know the locations of trigger zones. (Many of their howitzers and tanks are pre-sighted to set locations.) One notable advantage of a UAS, operating out of a DOT maintenance vehicle, is that it could deliver the explosive charge to the same pre-determined locations without requiring increasingly difficult to obtain and secure

military equipment or sending out skiers or snowmobilers. The use of skiers or snowmobilers often requires a human to make a sometimes dangerous and often slow trip to a trigger zone. Because UASs fly autonomously (without direct human control), they could potentially deliver control explosives with great accuracy and with minimal human risk or discomfort. This could result in roadways opening much sooner.

An obvious use of UAS is to replace a manned aircraft. A number of DOTs contract manned aircraft for avalanche control, but this is limited because the aircraft are costly. Hiring a helicopter, for example, can cost WSDOT $800 an hour (McCormack and Stimberis 2011). Operations involving "bombing" avalanches can also place the pilot and crew at risk. These aircraft and pilots are also not always immediately available, which can delay control operations and the ability to open roadways.

UASs could also enhance a DOT's overall operational efficiency by adding aerial surveillance capability where it would not previously be considered. For example, outside of the avalanche control season, UASs could provide traffic counts and surveillance along roadways where fixed cameras are not feasible.

(c) Transfer to Practice

This project will be completed in conjunction with avalanche control professionals from WSDOT and WYDOT, who will monitor the test flights and evaluate whether the results show that UASs will improve DOTs' ability to respond to avalanche conditions and open roads more efficiently. Included as a project team member will be Jamie Yount, who hase more than ten years' experience as an avalanche technician with WYDOT. As with the previous UW/WSDOT project, WSDOT's avalanche control staff will also have an active role in setting up and observing the tests. In addition, technicians from other states DOTs, as well as the U.S. Forest Service, have indicated interest in the tests and results. They will be welcome to participate in the project and to observe the test flights by using their own funding.

This project will produce a report detailing the procedures used in these tests and providing conclusions and recommendations on the use of UASs by state DOTs and other transportation agencies responsible for avalanche control. The report will provide an analysis of the effectiveness of the UASs and will evaluate whether their use would reduce closures of travel corridors and increase travel reliability. Other deliverables will include papers submitted to the Transportation Research Board's (TRB) Winter Maintenance Committee and to conferences oriented toward avalanche professionals, such as the International Snow Science Workshop.

The DOT avalanche control community is small, and many of the professionals know and communicate with each other. Effective techniques are often spread through word of mouth, as well through several trade publications and at national conferences. It is anticipated that the results of these tests will also be spread informally.

As the UAS vendors are also hungry to break into the civilian market, it is reasonable to expect that any vendor involved in these tests will actively market avalanche control applications as a potential feature of their aircraft.

3. INVESTIGATIVE APPROACH

Because of their newsworthy use by the military, many of us are aware of unmanned aircraft. As spinoffs from these defense applications, civilian versions of these aircraft are increasingly affordable, capable, and easy to operate (UAV Forum, 2011, Argrow 2009, Secretary of Defense 2005,). Commercially available unmanned aircraft systems

are small enough to be launched off a vehicle or from a road but can carry payloads, video cameras, and sensors and are able to use global positioning systems to autonomously fly pre-set flight plans. There is now a growing and competitive UAS industry, with a number of vendors selling systems designed for civilian applications (UAV Forum 2011).

Unmanned aircraft usage in non-military applications is not uncommon. Federal agencies have used UASs for a number of years for applications such as collecting scientific and weather data and assisting in border security (GAO 2008). In Washington state for example, the U.S. Geological Survey used a small (22-pound) UAS to collect seismic data from the crater on Mount St Helens (Patterson et al. 2005, Advanced Ceramics Research 2004).

The transportation profession has a growing interest in this technology. A 2003 U.S. Department of Transportation unmanned aerial vehicle workshop recognized the potential of this technology for transportation but also highlighted a number of institutional barriers, including the need for Federal Aviation Administration (FAA) certification (Brecher, Noronha, and Herold 2003). A 2005 survey of UAS use for traffic surveillance listed a handful of actual and potential applications (Puri 2005). For example, a series of flights by Ohio State University successfully tested UASs for monitoring transportation infrastructure and operations (TR News 2003).

While the product literature and the websites for a few UAS vendors list potential civilian applications for their aircraft that include snow surveillance and avalanche control, other than the tests performed by this project team, no actual use of UASs for avalanche control in North America or internationally was found.

Past Tests

The IDEA program will build off previous UAS test flights conducted in 2006 and 2007 by researchers at the UW and avalanche control operations staff from the WSDOT. These tests evaluated two commercially available small UASs, one fixed wing and one rotary wing (a helicopter), as both an avalanche control and aerial surveillance tool (McCormack 2011).

The proof of concept tests involved a series of flights centered on State Route 20 in the Cascade Mountains of north-central Washington state, where WSDOT annually conducts spring snow clearance and avalanche control operations. The tests evaluated the UASs' capabilities to

- survey a roadway and surrounding terrain
- operate off or next to a road
- inspect avalanche control target zones for people before the use of explosives
- deliver avalanche control explosives, and
- operate in mountain terrain and weather.

The researchers concluded that UASs have considerable potential, with the rotary wing version showing the most promise. One of the benefits of this technology is the ability to using video camera and sensor technology to provide real-time aerial surveillance of

avalanche terrain along roads. UASs might also detect people in areas that are targeted for the release of avalanche control explosives. The tests also indicated that UASs, using global positioning system navigation, might be able to deliver avalanche control explosives in pre-selected, inaccessible avalanche paths.

Because of institutional considerations, there are some notable limitations to flying a UAS; these are principally linked to the time consuming and restrictive process of obtaining FAA authorization to fly in order to address strict “see and avoid” rules (Weibel and Hansman 2004). Fortunately, the FAA is considering both technical and organizational solutions (Dalamagkidis et al 2008, Anand 2007, Federal Aviation Administration 2011). In addition, flying unmanned aircraft over lightly populated mountain areas reduces the difficulty of obtaining FAA authorization.

Objectives

This proposed project would expand on the previous WSDOT/UW test and conduct a series of flights that will further test UASs as a tool to enhance DOTs’ avalanche control operations and reduce the length of roadway closures.

This IDEA program test will advance the findings from the WSDOT/UW test. Because the project team has experience working with FAA regulations, they will be able to better tailor the flight applications to fully test the capabilities of UASs. This proposed project test will also benefit from a number of UAS software and aircraft-related technical improvements that have occurred over the last few years.

More specifically, the IDEA project will test the ability of small UASs, operated by DOT personnel, to efficiently and routinely

- survey explosive target zones for snow conditions, people, and other hazards before explosives are delivered
- autonomously and accurately drop explosives to trigger controlled avalanches
- serve as a low-cost platform for a range of sensors (LiDAR, infrared, video) that could support winter maintenance snow analysis needs
- operate in the mountains, in harsh weather and at high altitudes.

The project will also evaluate and document the process required by a DOT to obtain FAA approval to fly a UAS.

Work Plan

The following stages will be completed as part of this effort.

1. Select the flight test area, design the flight tests, and select the aircraft’s capabilities. In this initial stage, the flight parameters will be set and the roadway for the flight test area will be selected. It is anticipated that the flights will take place above the same mountainous roadway that was used for the previous WSDOT/UW UAS avalanche control tests. This test area was centered on State Route 20 in the Cascade Mountains of north-central Washington state. This road was selected because it is where WSDOT annually conducts spring snow clearance and avalanche control operations. The road, while a major cross-state highway, is closed to traffic in the spring and is both an ideal and realistic location for operating a UAS.

Because this project will be completed in partnership with Wyoming DOT, if the SR 20 site is not available, the test could be conducted on Teton Pass or another Wyoming

roadway where routine avalanche control operations are used to keep the roadway safe and open.

In conjunction with avalanche professionals and maintenance staff at WSDOT and WYDOT, the aircraft performance parameters and onboard sensor/camera capabilities will also be established in this stage. These specifications will be used in stage two to obtain FAA approval and in stage three to guide the hiring of a UAS operator.

It is anticipated that an avalanche control UAS should be selected and tested for its capabilities to meet the following overall requirements:

- carry a camera that will allow real-time surveying of terrain surrounding the roadway and avalanche paths and start zones
- carry a camera or sensors (such as infra-red devices) to inspect avalanche control target zones for people before the use of ordnance and explosives
- have remote release capabilities to autonomously and accurately drop avalanche control explosives weighing a minimum of 4 pounds
- operate in mountainous terrain and harsh weather
- operate above 10,000 feet
- be affordable to a DOT; the aircraft, ground control equipment, training, and maintenance should cost less than $500,000
- be operable and maintainable, with appropriate training and certification, by DOT staff.

On the basis of the UW/WSDOT tests, it is anticipated that UASs of interest will be portable so that they can be moved among roadside sites used to stage avalanche control operations. The UASs that generally fit this category are man-portable systems that can be launched by hand or tactical UASs that weigh between 50 to 1,000 pounds (UAV Forum 2011). These UASs include both fixed and rotary wing aircraft (helicopters) that have vertical takeoff and landing capabilities.

These two types of UASs have notable trade-offs because fixed wing UASs are simpler to fly, are a more thoroughly proven technologically, and have better endurance, but they are less mobile than rotary wing UASs and thus less capable of serving as camera and sensor platforms. Fixed wing aircraft also often require cleared, flat areas to land, which could pose a challenge in snowy conditions, whereas rotary wing aircraft do not. The IDEA program will flight test at least two aircraft types, with one fixed wing and one rotary wing.

2. Obtain Federal Aviation Administration approval. An FAA Certificate of Authorization (COA) is required for all UAS flights. The FAA's application process is an online process that requires several months. The application requires technical details about the aircraft, the pre-defined flight area (selected in stage one), and a certificate of airworthiness for the unmanned aircraft. As public agencies, DOTs and the UW have an advantage in that they can certify the airworthiness of any UAS in the test. The COA, which is good for a year, stipulates a number of communications protocols. The COA application process and the resulting flights will be coordinated with WSDOT’s Aviation office or WYDOT’s Aeronautics division. The aviation staff’s involvement will ensure that the proper air traffic pre-flight notification is completed before the flight tests.

3. Contract with a UAS owner. A UAS manufacturer or a research organization that owns UASs will be placed under contract to complete the test flights. The unmanned aircraft selected for this proposed project will be required to meet the capabilities listed above. The UAS system owner will be responsible for operating the aircraft. The funding requested from the IDEA program will support at least one set of rotary wing flights and two sets of fixed flights—three different UASs.

4. Conduct the flight tests. This step will involve the actual flights above the test site. The tests will occur over several days in winter conditions and will involve multiple flights to complete the tasks listed in the objectives above. This step will require the scheduling and coordination of a range of participants, including the following:

- the project team to observe the flights and document results
- avalanche control technicians from different DOTs, who will be invited to observe the flights and provide feedback on the usefulness of the UAS data and on the ability of the UAS to accurately drop simulated avalanche control charges
- as needed, DOT field crews to provide traffic control and safety during the flights
- a DOT's aviation staff to coordinate with regional air traffic control and communicate, if needed, with the FAA
- the aircraft owner to transport, maintain, and operate the UAS.

5. Document the findings. This project will produce a draft and final report that will detail the procedures and findings from the project. The results will be published in both academic journals and in a final report designed for use by transportation agency professionals.

The possible impacts of this technology as a tool for improving roadway reliability will be assessed. This will include the comparison of avalanche control tasks both with and without UAS technology, with an emphasis on the ability of this technology to reduce the duration of road closures. The report will also provide information about the FAA certification process, UAS capabilities and limitations, and costs, and will provide conclusions and recommendations on the use of UASs for avalanche control staff at state DOTs.

Given the high level of interest in UAS technology found after the WSDOT/UW test, it is anticipated that presentations about this project will also be given at conferences such as the TRB Annual meeting. The findings from the project should also be of interest both to academics researching unmanned aircraft technology and applications and to transportation agency staff curious about their use in the transportation world.

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4. KEY PERSONNEL AND FACILITIES

Dr. Edward McCormack will be the project's Principal Investigator. He will be responsible for setting up the tests, developing the contract with the vendors, obtaining the FAA certificate of authorization, and completing the report's documentation.

Dr. McCormack is both a Research Assistant Professor in Civil and Environmental Engineering and a Principal Research Engineer with the Washington State Transportation Center (TRAC) at the University of Washington. He has over 25 years' experience evaluating the use of innovative technologies to address transportation mobility issues.

Dr. McCormack led the UW/WSDOT effort that evaluated the transportation applications of small unmanned aircraft and determined that UASs have considerable potential to support avalanche control operations. He is currently leading a project (linked to a larger effort led by the University of California-Davis) that is evaluating the value of mobile LiDAR technology for the Washington State Department of Transportation. Dr. McCormack is also leading an effort to use GPS data from commercial trucking industry systems to quantify roadway network performance. He was a member on the team that recently completed the Strategic Highway Research Program 2 L11, Evaluating Alternative Operations Strategies to Improve Travel Time Reliability.

As support staff to WSDOT's Advanced Technology Branch, Dr. McCormack managed a 10-year-long series of field operational tests that explored the use of technology to facilitate truck movements over the Washington/British Columbia international border. This program included testing the use of electronic transponder (RFID) door seals (e-seals) on shipping containers. Prior to working at the university, Dr. McCormack was a consultant running traffic and travel demand models. He is also an experienced backcountry skier with training in avalanche safety. He received his Master's degree in Civil Engineering and a B.A. and Ph.D. in Geography from the University of Washington.

Jamie Yount is a key investigator for this proposed effort. He will help to design the test flights, ensure that the results of the tests are usable from the perspective of a DOT's avalanche control operations, and assist in completing the project documentation.

Mr. Yount has been an avalanche technician with the Wyoming Department of Transportation since 2002. He graduated with a Bachelors of Science in Meteorology from the University of Utah in Salt Lake City, ski patrolled at Bridger Bowl Ski area in Bozeman, Montana, and has over 15 years of backcountry ski experience in the mountains of Idaho, Utah, Montana, Wyoming, and Alaska. He is responsible for

avalanche forecasting and control on slide paths that impact Wyoming state and federal highways on Teton Pass, the Hoback River Canyon, the Snake River Canyon, and the Jackson area. He is also the Intermountain South Representative for the American Avalanche Association, a young member on the Transportation Research Board Winter Maintenance Committee, and a member of the Teton County Search and Rescue Team.

Mr. Yount has presented avalanche research at the 2004 International Snow Science Workshop in Jackson, Wyoming, the 2004 Snow Engineering Conference in Davos, Switzerland, the 2008 International Snow Science Workshop in Whistler, BC, and the 2010 Transportation Research Board in Washington, DC. He teaches avalanche education to novices and experts and winter weather forecasting courses for avalanche professionals and the United States Marine Corp Mountain Warfare Training Center.

This project will have access to avalanche control staff from both WSDOT and Wyoming DOT. Both these agencies have active avalanche control programs and roadways that can serve as test sites for this project.

Facilities

This project will be conducted through the Washington State Transportation Center (TRAC) at the University of Washington. TRAC is part of a cooperative research arrangement with the WSDOT. TRAC's primary purpose is to facilitate research on the transportation problems of the region and nation. The objective of TRAC's applied research is to improve the effectiveness, efficiency, safety, economy, and energy conservation of the transport of people and goods throughout Washington and the country. The results of our efforts and collaborations are innovative solutions to pressing problems in transportation system design, construction, operations, and maintenance.

TRAC resources available for this project include a professional staff to aid in the writing, editing, and graphics involved in report production; microcomputer facilities; and conference and drafting facilities. The University libraries, with more than 5 million volumes, provide an outstanding collection of books, periodicals, research reports, publications, and other materials. In addition, the facilities of the Washington State Department of Transportation's library in Olympia will be available for the project.

5. OTHER RELATED PROPOSALS

The previous UAS test discussed in this proposal was funded by US DOT's joint program office and WSDOT. This test was conducted in 2006 and 2007 and is documented in McCormack and Stimberis (2010) and WSDOT (2008).

Attachment 2

IDEA BUDGET SUMMARY

Project Title:______________________________

Principal Investigator: Edward McCormack____________________

Organization: University of Washington ____________________

Phone: 206 543-3348__________ Project Duration (Months): 12__________

(Please attach budget detail as needed)

FUNDING REQUESTED FROM IDEA PROGRAM

PERSONNEL:	# hours x $/hour	IDEA Costs	Cost Sharing
Principal Investigator:	180 x $64.45	= $11,601	$______
________:	_____ x $_____	= $______	$______
Other staff: Support Staff (Report Production) :	20 x $_54.27____	= $1,085	$______
	Subtotal	$11,601	$______

CONSULTANTS AND SUBCONTRACTORS: (specify)
Contracting Unmanned Aircraft Systems Vendors (Only the first $25,000 has UW overhead)

Subtotal ....$55,000 $______

MATERIALS & EQUIPMENT: (indicate items exceeding $1,000)

Subtotal ....$______ $______

OTHER DIRECT COSTS: (specify)
Travel to IDEA committee meeting and to theproject test site

Subtotal $2,500
$______ ....

OVERHEAD COSTS: (54%) ....$21,701 $______

GENERAL AND ADMINISTRATIVE: (0%)..................................$______ $______

Total Cost: $91,887

PROPOSED COST SHARING (if any)

Direct (cash) contribution from proposing organization:	$______
In-kind contribution from proposing organization:	$______
Direct funding from other sources (specify): Wyoming DOT	$30,000
Value of staff, etc., contributed by other sources: WYDOT/WSDOT Staff	$2,780

Total Project Budget: $124,667

Signature:____________________ Date:__________

BUDGET DETAILS

CONSULTANTS AND SUBCONTRACTORS: This category includes $55,000 requested from the IDEA program combined with a $25,000 match from Wyoming DOT for a total of $80,000 to hire at least two fixed wing and one rotary wing UAS vendor for the project's test flight. On the basis of the project team's previous tests, this assumes that two days of flight tests by a rotary wing UAS vendor will cost $40,000 and two days by a fixed wing vendor will cost $15,000. The contract with the vendor will include all the its costs, including travel, aircraft transportation, configuring the aircrafts for the test flights, operating the aircraft, and assisting the research team in documenting project results.

OTHER DIRECT COSTS: These include one trip from Seattle to Washington, DC, for a project briefing with the IDEA committee (two-night stay plus airfare and per-diem: $900) and four trips to the project test site by Edward McCormack and Jamie Yount (six nights' hotel stay, local travel, per-diem and airfare between Wyoming and Washington state: $1,600).

Liability Statement—Revised August 1997

This signature of an authorized representative of the proposing agency is required on the following unaltered statement in order for the IDEA Program to accept the agency's proposal for consideration. **Proposals submitted without this executed and unaltered statement by the proposal deadline will be summarily rejected.** An executed, unaltered statement indicates the agency's intent and ability to execute a contract that includes the provisions below.

Proposing Agency:

Name Title

Signature Date

CONTRACTOR LIABILITY

(a) The parties agree that the contractor and its employees and agents ("Contractor") will be primarily responsible for performing the work required under the contract, and shall therefore be legally responsible for, and shall indemnify and hold the Academy harmless for all claims asserted against the Academy, its committee members, officers, employees, and agents, by any third parties, whether or not represented by a final judgment, if such claims arise out of or result from Contractor's negligent or wrongful acts in performing such work, including all claims for bodily injury (including death), personal injury, property damage, and other losses, liabilities, costs, and expenses (including but not limited to attorneys fees).

(b) With respect to entities of State government that are subject to State law restrictions on their ability to indemnify and hold harmless third parties ("Restricted State Entities"), the obligation to indemnify and hold harmless the Academy in Paragraph (a) shall apply to the full extent permitted by applicable State law. In addition, each Restricted State Entity executing this contract represents and warrants that no part of any research product or other material delivered by such Restricted State Entity to the Academy ("Work Product") shall include anything of an obscene, libelous, defamatory, disparaging, or injurious nature; that neither the Work Product nor the title to the Work Product will infringe upon any copyright, patent, property right, personal right, or other right; and that all statements in the Contractor's proposal to the Academy and in the Work Product are true to the Contractor's actual knowledge and belief, or based upon reasonable research for accuracy.

(c) The term "wrongful act" as used herein shall include any tortious act or omission, willful misconduct, failure to comply with Federal or state governmental requirements, copyright or patent infringement, libel, slander or other defamatory or disparaging statement in any written deliverable required under the contract, or any false or negligent statement or omission made by Contractor in its proposal to the Academy.

(d) The obligations in paragraph (a) of this clause to indemnify and hold harmless the Academy shall not extend to claims, damages, losses, liabilities, costs, and expenses to the extent they arise out of the negligent or wrongful acts or omissions of the Academy, its committee members, officers, employees, and agents.

(e) Both the Academy and Contractor shall give prompt notice to each other upon learning of the assertion of any claim, or the commencement of any action or proceeding, in respect of which a claim under this paragraph may be sought, specifying, if known, the facts pertaining thereto and an estimate of the amount of the liability arising therefrom, but no failure to give such notice shall relieve the Academy or Contractor of any liability hereunder except to the extent actual prejudice is suffered thereby.

(f) The Academy and Contractor agree to cooperate with each other in the defense of any claim, action, or legal proceeding arising out of or resulting from Contractor's performance of the work required under this contract, but each party shall control its own defense. The Academy shall also have the option in its sole discretion to permit Contractor or its insurance carrier to assume the defense of any such claims against the Academy.

(g) The obligations under this clause survive the termination, expiration, or completion of performance under this contract.